MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2015/2016

EPM2036 – CONTROL THEORY

(TE, RE, BE)

8 OCTOBER 2015
9.00 a.m - 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 6 pages including cover page with 5 Questions only.

2. Attempt **FOUR** out of **FIVE** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Determine the closed loop transfer function $\frac{C(s)}{R(s)}$ of the system whose signal flow graph is shown in Figure Q1 (a) using Mason's gain formula.

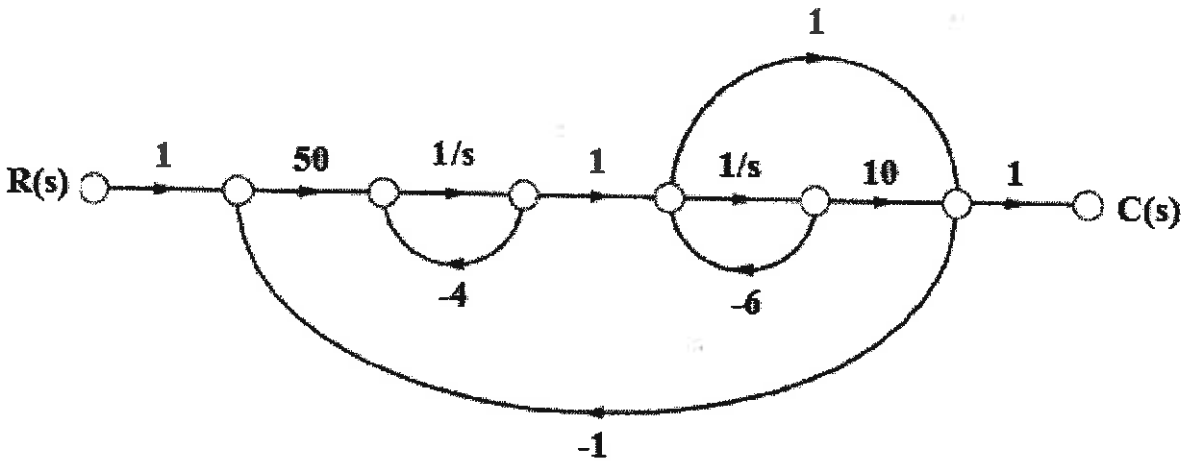

Figure Q1 (a)

[17 marks]

(b) A two mass model of the robot is shown in Figure Q1(b). *f(t)* represents the force applied, y_1 and y_2 represents displacements, M_1 and M_2 denotes Mass, B denotes coefficient of friction and K is the spring constant. Write the equations of motion in s-domain. You need not solve these equations.

[8 marks]

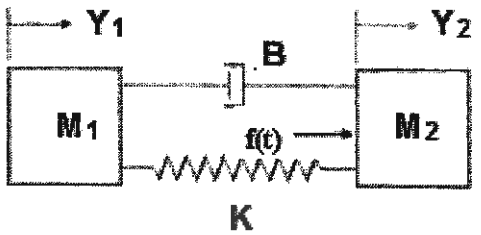

Figure Q1(b)

Continued...

Question 2

(a) Consider the system shown in Figure Q2(a). Determine the value of k such that the damping ratio, ζ is 0.5.

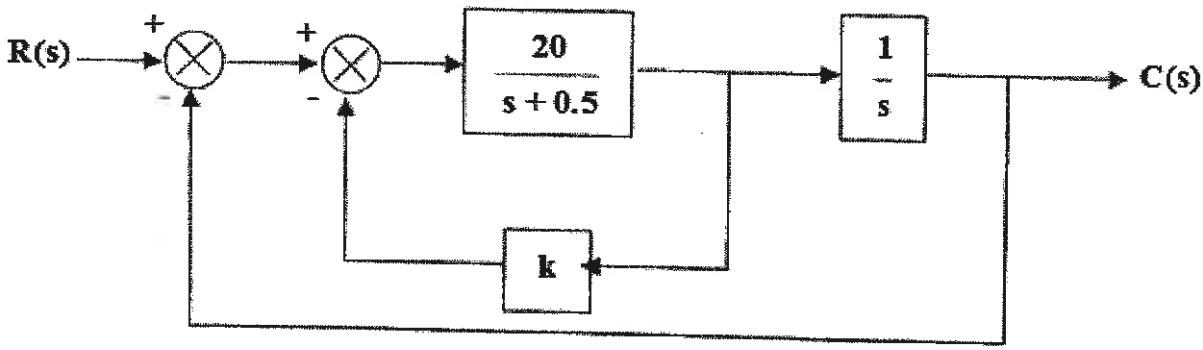

Figure Q2(a)

[9 marks]

(b) Consider the open loop transfer function of unity feedback system,

$$G(s) = \frac{30}{s(s+15)}$$

Determine the position, velocity and acceleration error constants.

[6 marks]

(c) A negative unity feedback system has open loop function,

$$G(s) = \frac{10}{s^3 + 2s^2 + ks + s}$$

Determine the range of k for a stable system using Routh Hurwitz criteria.

[10 marks]

Continued...

Question 3

(a) The open loop transfer function of a unity feedback system is

$$G(s) = \frac{25}{s^2 + 6s}$$

Find the following terms of second order closed-loop system:

(i) Natural frequency(ω_n)

(ii) Damping ratio(ζ)

(iii) Peak overshoot

[6 + 2 + 2 marks]

(b) The open loop transfer function of a feedback control system is given by

$$G(s)H(s) = \frac{K}{s(s+1)(s+2)}$$

Find the range of K for stability using Nyquist Criterion.

[15 marks]

Continued...

Question 4

A closed loop feedback system is shown in Figure Q4.

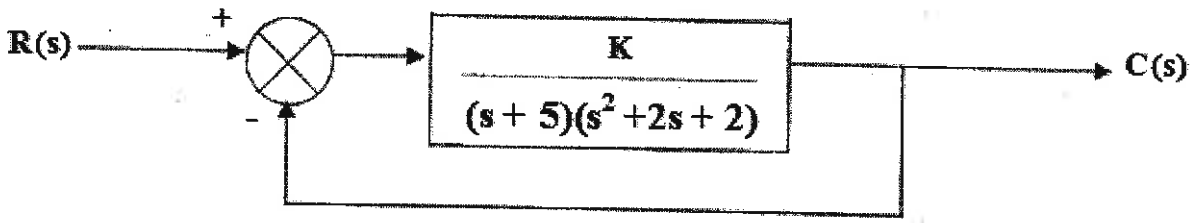

Figure Q4

(i) Find the starting and ending points of the system

(ii) Find the number of branches

(iii) Determine the angle of asymptotes and intersection of asymptotes

(iv) Determine the angle of departure.

(v) Determine the range of K for the system to be stable

(vi) Sketch the root locus in graph sheet.

[4 + 1 + 4 + 4 + 8 + 4 marks]

Continued...

Question 5

(a) Define the following terms.

(i) Resonant Peak

(ii) Resonant Frequency

(iii) Phase cross over frequency.

[2 + 2 + 2 marks]

(b) A feedback system with Proportional-Integral (PI) controller is shown in Figure Q5(b).

Design the PI controller so that it meets the following two specifications.

Specification 1: The steady-state error is no more than 0.05 for a unit-ramp input.

Specification 2: The system is stable or on the boundary of stability.

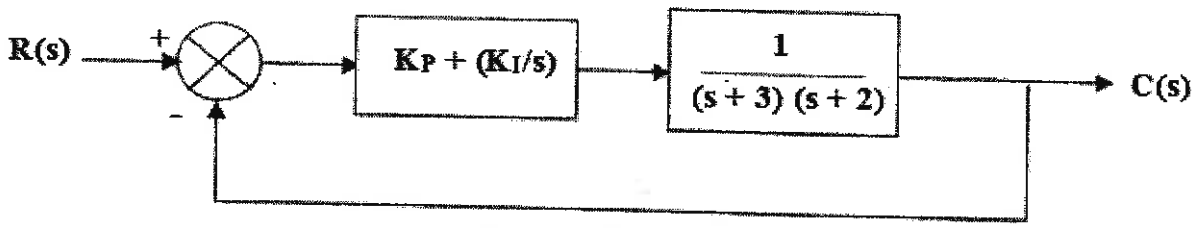

Figure Q5(b)

Determine the following:

(i) Critical values for K_P and K_I

(ii) Closed-loop transfer function of the system $\frac{C(s)}{R(s)}$ using the critical values in (i).

[16 + 3 marks]

End of the paper